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# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.

35,C14386

First Named Inventor or Application Identifier

SEIJI MISHIMA

Express Mail Label No.

Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

## ADDRESS TO:

1. ☐ Fee Transmittal Form  
(Submit an original, and a duplicate for fee processing)2. ☐ Applicant claims small entity status.  
See 37 CFR 1.27.3. ☒ Specification Total Pages 484. ☒ Drawing(s) (35 USC 113) Total Sheets 115. ☒ Oath or Declaration Total Pages 1a. ☒ Newly executed (original or copy)b. ☐ Copy from a prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed)i. ☐ **DELETION OF INVENTOR(S)**  
Signed Statement attached deleting  
inventor(s) named in the prior application, see  
37 CFR 1.63(d)(2) and 1.33(b).6. ☒ Application Data Sheet. See 37 CFR 1.767. ☐ CD-ROM or CD-R in duplicate, large table or Computer  
Program (Appendix)8. ☐ Nucleotide and/or Amino Acid Sequence Submission  
(if applicable, all necessary)a. ☐ Computer Readable Form (CRF)

b. Specification Sequence Listing on:

i. ☐ CD-ROM or CD-R (2 copies); orii. ☐ paperc. ☐ Statements verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

9. ☒ Assignment Papers (cover sheet & document(s))10. ☐ 37 CFR 3.73(b) Statement ☐ Power of Attorney  
(when there is an assignee)11. ☐ English Translation Document (if applicable)12. ☐ Information Disclosure  
Statement (IDS)/PTO-1449 ☐ Copies of IDS  
Citations13. ☒ Preliminary Amendment14. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)15. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)16. ☐ Other: \_\_\_\_\_

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No. PCT/JP00/01024  
 Prior application information: Examiner \_\_\_\_\_ Group/Art Unit: \_\_\_\_\_

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied herewith, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

## 18. CORRESPONDENCE ADDRESS

☒ Customer Number or Bar Code Label (Insert Customer No. or Attach bar code label here) or ☐ Correspondence address below

NAME

Address

City

State

Zip Code

Country

Telephone

Fax

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
TOTAL CLAIMS (37 CFR 1.16(c))		139*-20 =	119	X \$ 18.00 =	\$2142.00
INDEPENDENT CLAIMS (37 CFR 1.16(b))		8-3 =	5	X \$ 80.00 =	\$ 400.00
MULTIPLE DEPENDENT CLAIMS (if applicable) (37 CFR 1.16(d))				\$270.00 =	\$ 270.00
				BASIC FEE (37 CFR 1.16(a))	\$ 710.00
Total of above Calculations =					\$3522.00
Reduction by 50% for filing by small entity (Note 37 CFR 1.9, 1.27, 1.28)					0
TOTAL =					\$3522.00

## 19. Small entity status

- a. ☐ A small entity statement is enclosed
- b. ☐ A small entity statement was filed in the prior nonprovisional application and such status is still proper and desired.
- c. ☐ Is no longer claimed.

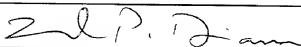
20. ☒ A check in the amount of \$ 3522.00 to cover the filing fee is enclosed.

21. ☒ A check in the amount of \$ 40.00 to cover the recordal fee is enclosed.

22. The Commissioner is hereby authorized to credit overpayments or charge the following fees to Deposit Account No. 06-1205.

- a. ☒ Fees required under 37 CFR 1.16.
- b. ☒ Fees required under 37 CFR 1.17.
- c. ☐ Fees required under 37 CFR 1.18.

## SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

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SIGNATURE		29,296
DATE	October 23, 2000	

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APPLICATION INFORMATION

Title Line One:: METHOD OF MANUFACTURING ELECTRONIC DEVICE,  
Title Line Two:: ELECTRON SOURCE SUBSTRATE, AND IMAGE FORMING  
Title Line Three:: APPARATUS, AND APPARATUS FOR MANUFACTURING  
Title Line Four:: ELECTRONIC DEVICE AND ELECTRON SOURCE  
Title Line Five:: SUBSTRATE

Total Drawing Sheets:: 11  
Formal Drawings?: Yes  
Application Type:: Utility  
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REPRESENTATIVE INFORMATION

Representative Customer Number:: 05514

PRIOR FOREIGN APPLICATIONS

Foreign Application One:: 11-047095  
Filing Date:: 02-24-1999  
Country:: JAPAN  
Priority Claimed:: Yes

35.C14386

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: )  
: Examiner: Unassigned  
SEIJI MISHIMA ET AL. )  
: Group Art Unit: Unassigned  
Continuation of International )  
Application No.: PCT/JP00/01024:  
: )  
Filed: Herewith :  
: )  
For: METHOD OF MANUFACTURING )  
: ELECTRONIC DEVICE, )  
: ELECTRON SOURCE SUBSTRATE, )  
AND IMAGE FORMING :  
APPARATUS, AND APPARATUS )  
FOR MANUFACTURING :  
ELECTRONIC DEVICE AND )  
ELECTRON SOURCE SUBSTRATE : October 23, 2000

Assistant Commissioner for Patents  
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir:

Prior to examination on the merits, please amend  
the above-identified application as follows:

IN THE SPECIFICATION:

Immediately after the title, please insert the  
following:

--This application is a continuation of  
International Application No. PCT/JP00/01024, filed February  
23, 2000, which claims the benefit of Japanese Patent

Application No. 11-047095, filed February 24, 1999.--

REMARKS

The specification has been amended above to make reference to parent International Application No. PCT/JP00/01024 (filed February 23, 2000) and Japanese Patent Application No. 11-047095 (filed February 24, 1999), from which International Application No. PCT/JP00/01024 claims benefit.

An early and favorable action on the merits is respectfully requested.

Applicant's undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

  
Attorney for Applicant

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# SPECIFICATION

METHOD OF MANUFACTURING ELECTRONIC DEVICE, ELECTRON  
SOURCE SUBSTRATE, AND IMAGE FORMING APPARATUS, AND  
5 APPARATUS FOR MANUFACTURING ELECTRONIC DEVICE AND  
ELECTRON SOURCE SUBSTRATE

## Technical Field

The present invention relates to an electronic  
10 device manufacturing method and a manufacturing  
apparatus therefor and, more particularly, to a  
manufacturing method for an electronic device by the  
step of applying, to a substrate, droplets of a liquid  
containing the formation material of a member which  
15 constitutes the electronic device, and a manufacturing  
apparatus therefor.

## Background Art

As a method of easily manufacturing a  
20 surface-conduction type electron-emitting element at  
low cost, there is conventionally proposed a method  
like the one disclosed in Japanese Laid-Open Patent  
Application No. 8-171850 in which droplets of a  
metal-containing solution are discharged onto a  
25 substrate using a droplet discharge unit to form  
element electrodes and a conductive film between them,  
thereby manufacturing an element, as shown in Fig. 11.

In Fig. 11, reference numeral 1 denotes a substrate; 2 and 3, element electrodes; 4, a conductive film; and 5, an electron-emitting portion.

5       An electron source substrate having  
electron-emitting elements arrayed in a matrix, and an  
image forming apparatus are formed on an insulating  
substrate.

10       As another example of manufacturing an electronic  
device other than the electron-emitting element and  
electron source by using an ink-jet method, Japanese  
Laid-Open Patent Application No. 8-327816 discloses a  
color filter manufacturing method using the ink-jet  
method.

15       However, forming the building component of the  
electronic device using the ink-jet method suffers the  
following problems. That is, discharge of a solution  
is inhibited by a gas dissolved in the solution when  
the solution containing a material for forming the  
building component of the electronic device contacts  
20       air, and by bubbles and the like mixed in injecting the  
solution into the droplet discharge unit. As a result,  
the droplet discharge amount may vary. The droplet  
discharge direction may be influenced by this state,  
and the landing position when a droplet lands on the  
25       insulating substrate may offset from a design value.

In addition, the temperature of the solution  
changes depending on the ambient temperature of the

unit to change physical properties such as the viscosity of the solution. The droplet discharge amount may vary. The droplet discharge direction may be influenced by this state, and the landing position  
5 when a droplet lands on the insulating substrate may offset from a design value.

Hence, the yield in manufacturing an electronic device is difficult to increase, and the production cost increases. In the electron source, the uniformity  
10 of the conductive thin film of an electron-emitting element is impaired to decrease the yield of an electron source substrate.

It is, therefore, an object of the present invention to provide an electronic device manufacturing  
15 method and manufacturing apparatus which can discharge a solution to an accurate position on a substrate, and are excellent in reproducibility of the characteristics of a manufactured electronic device.

It is another object of the present invention to  
20 provide a manufacturing method and manufacturing apparatus which can discharge a solution to an accurate position on a substrate, for an electron source having a plurality of electron-emitting portions with uniform electron emission characteristics.

It is still another object of the present invention to provide a manufacturing method for a  
25 high-quality image forming apparatus having uniform



emission luminance.

#### Disclosure of the Invention

According to one aspect of the present invention,  
5 an electronic device manufacturing apparatus is  
characterized by comprising gas removal means for  
removing a gas dissolved in a liquid containing a  
formation material of a member constituting an  
electronic device, droplet discharge means for  
10 discharging droplets of the liquid, and means for  
controlling relative positions of the droplet discharge  
means and a substrate on which the electronic device is  
formed, wherein the droplets are applied to a  
predetermined position on the substrate.

15 In this invention, the gas removal means comprises  
a closed vessel filled with a membrane formed from a  
semi-transmitting film capable of transmitting a gas,  
and a vacuum unit for evacuating the closed vessel.

In this invention, the gas removal means comprises  
20 means for adjusting a flow rate of the liquid in the  
membrane.

In this invention, the gas removal means comprises  
means for detecting an amount of gas contained in the  
liquid.

25 In this invention, the gas removal means comprises  
a vacuum unit, and exposes a solution containing the  
liquid to vacuum.

In this invention, the vacuum unit has a variable exhaust speed.

In this invention, the gas removal means comprises means for detecting a vacuum degree of the vacuum unit.

5 In this invention, the droplet discharge means generates a bubble in the liquid using thermal energy, and discharges the liquid on the basis of generation of the bubble.

10 In this invention, the droplet discharge means discharges the liquid using kinematic energy.

According to another aspect of the present invention, an electronic device manufacturing apparatus comprises means for adjusting a temperature of a liquid containing a formation material of a member  
15 constituting the electronic device, droplet discharge means for discharging droplets of the liquid, and means for controlling relative positions of the droplet discharge means and a substrate on which the electronic device is formed, wherein the droplets are applied to a  
20 predetermined position on the substrate.

In this invention, the droplet discharge means generates a bubble in the liquid using thermal energy, and discharges the liquid on the basis of generation of the bubble.

25 In this invention, the droplet discharge means discharges the liquid using kinematic energy.

In this invention, the electronic device includes

an electron source having a plurality of  
electron-emitting elements.

In this invention, each electron-emitting element  
includes an electron-emitting element having a pair of  
5 conductors arranged at a gap.

In this invention, the droplet discharge means  
includes means for discharging droplets of the liquid  
containing a formation material of the conductors.

In this invention, the electron source includes an  
10 electron source having a plurality of electron-emitting  
element arrays each formed by connecting a plurality of  
electron-emitting elements between a pair of wiring  
lines.

In this invention, the electron source includes an  
15 electron source constituted by connecting a plurality  
of electron-emitting elements in a matrix by a  
plurality of row-direction wiring lines and a plurality  
of column-direction wiring lines.

According to still another aspect of the present  
20 invention, an electron source substrate manufacturing  
apparatus for manufacturing an electron source  
substrate having a plurality of pairs of element  
electrodes formed on a substrate, conductive films each  
having an electron-emitting portion formed between each  
25 pair of element electrodes, and a voltage application  
terminal to each element electrode, is characterized by  
comprising gas removal means for removing a gas

dissolved in a solution containing a metal element,  
droplet discharge means for discharging droplets of the  
solution containing the metal element, and means for  
controlling relative positions of the droplet discharge  
5 means and the substrate, wherein the droplets are  
applied to a predetermined position on the substrate.

In this invention, the gas removal means comprises  
a closed vessel filled with a membrane formed from a  
semi-transmitting film capable of transmitting a gas,  
10 and a vacuum unit for evacuating the closed vessel.

In this invention, the gas removal means comprises  
means for adjusting a flow rate of a metal solution in  
the membrane.

In this invention, the gas removal means comprises  
15 means for detecting an amount of gas contained in the  
solution.

In this invention, the gas removal means comprises  
a vacuum unit, and exposes a solution containing a  
metal solution to vacuum.

20 In this invention, the vacuum unit has a variable  
exhaust speed.

In this invention, the gas removal means comprises  
means for detecting a vacuum degree of the vacuum unit.

According to still another aspect of the present  
25 invention, an electron source substrate manufacturing  
apparatus for manufacturing an electron source  
substrate having a plurality of pairs of element

electrodes formed on a substrate, conductive films each having an electron-emitting portion between each pair of element electrodes, and a voltage application terminal to each element electrode, is characterized by comprising means for adjusting a temperature of a solution containing a metal element, droplet discharge means for discharging droplets of the solution containing the metal element, and means for controlling relative positions of the droplet discharge means and the substrate, wherein the droplets are applied to a predetermined position on the substrate.

In this invention, the droplet discharge means generates a bubble in the solution using thermal energy, and discharges the solution on the basis of generation of the bubble.

In this invention, the droplet discharge means discharges the solution using kinematic energy.

In this invention, the solution containing the metal element contains a formation material of the conductive film in which the electron-emitting portion is formed.

According to still another aspect of the present invention, an electronic device manufacturing method is characterized by comprising the gas removal step of removing a gas dissolved in a liquid containing a formation material of a member constituting an electronic device, and the droplet discharge step of

discharging droplets by droplet discharge means while  
controlling relative positions of the droplet discharge  
means for discharging droplets of the liquid and a  
substrate on which the electronic device is formed,  
5 thereby applying the droplets to a predetermined  
position on the substrate.

In this invention, the gas removal step comprises  
controlling a concentration of the gas dissolved in the  
liquid so as to be kept at a default value.

10 In this invention, the droplet discharge means  
generates a bubble in the liquid using thermal energy,  
and discharges a solution on the basis of generation of  
the bubble.

15 In this invention, the droplet discharge means  
discharges the liquid using kinematic energy.

According to still another aspect of the present  
invention, an electronic device manufacturing method is  
characterized by comprising the temperature adjusting  
step of adjusting a temperature of a liquid containing  
20 a formation material of a member constituting an  
electronic device, and the droplet discharge step of  
discharging droplets by droplet discharge means while  
controlling relative positions of the droplet discharge  
means for discharging droplets of the liquid and a  
25 substrate on which the electronic device is formed,  
thereby applying the droplets to a predetermined  
position on the substrate.

In this invention, the droplet discharge means generates a bubble in the liquid using thermal energy, and discharges the liquid on the basis of generation of the bubble.

5           In this invention, the droplet discharge means discharges the liquid using kinematic energy.

In this invention, the electronic device includes an electron source having a plurality of electron-emitting elements.

10           In this invention, each electron-emitting element includes an electron-emitting element having a pair of conductors arranged at a gap.

In this invention, the liquid includes a liquid containing a formation material of the conductors.

15           In this invention, the electron source includes an electron source having a plurality of electron-emitting element arrays each formed by connecting a plurality of electron-emitting elements between a pair of wiring lines.

20           In this invention, the electron source includes an electron source constituted by connecting a plurality of electron-emitting elements in a matrix by a plurality of row-direction wiring lines and a plurality of column-direction wiring lines.

25           According to still another aspect of the present invention, an electron source substrate manufacturing method of manufacturing an electron source substrate

having a plurality of pairs of element electrodes  
formed on a substrate, conductive films each having an  
electron-emitting portion formed between each pair of  
element electrodes, and a voltage application terminal  
5 to each element electrode, is characterized by  
comprising the gas removal step of removing a gas  
dissolved in a solution containing a metal element, and  
the droplet discharge step of discharging droplets by  
droplet discharge means while controlling relative  
10 positions of the substrate and the droplet discharge  
means for discharging droplets of the solution, thereby  
applying the droplets to a predetermined position on  
the substrate.

In this invention, the gas removal step comprises  
15 controlling a concentration of the gas dissolved in the  
solution so as to be kept at a default value.

In this invention, the droplet discharge means  
generates a bubble in the solution using thermal  
energy, and discharges the solution on the basis of  
20 generation of the bubble.

In this invention, the droplet discharge means  
discharges the solution using kinematic energy.

According to still another aspect of the present  
invention, an electron source substrate manufacturing  
25 method of manufacturing an electron source substrate  
having a plurality of pairs of element electrodes  
formed on a substrate, conductive films each having an



electron-emitting portion formed between each pair of  
element electrodes, and a voltage application terminal  
to each element electrode, is characterized by  
comprising the temperature adjusting step of adjusting  
5 a temperature of a solution containing a metal element,  
and the droplet discharge step of discharging droplets  
by droplet discharge means while controlling relative  
positions of the substrate and the droplet discharge  
means for discharging droplets of the solution, thereby  
10 applying the droplets to a predetermined position on  
the substrate.

In this invention, the droplet discharge means  
generates a bubble in the solution using thermal  
energy, and discharges the solution on the basis of  
15 generation of the bubble.

In this invention, the droplet discharge means  
discharges the solution using kinematic energy.

In this invention, the solution containing the  
metal element contains a formation material of the  
20 conductive film in which the electron-emitting portion  
is formed.

According to still another aspect of the present  
invention, an image forming apparatus manufacturing  
method of manufacturing an image forming apparatus  
25 having an electron source substrate and a  
light-emitting member which emits light upon  
irradiation of electrons from the electron source

substrate, is characterized in that the electron source substrate is manufactured by the electron source substrate manufacturing method described above.

In this case, the electronic device in the present invention includes a color filter for a liquid crystal display, a driving circuit for various displays such as a liquid crystal display, plasma display, and electron beam display, and an electron source substrate itself. The building member of the electronic device formed by the manufacturing method and manufacturing apparatus of the present invention includes a filter element particularly in the color filter, a conductor patterned on a circuit board or an insulator for insulating conductors in the driving circuit for various displays, and building members of a plurality of electron-emitting elements or conductors for connecting the electron-emitting elements to driving wiring lines in the electron source substrate.

By these apparatus and method, the present invention can discharge a solution to an accurate position on a substrate, and can manufacture an electronic device excellent in reproducibility of characteristics.

By these apparatus and method, the present invention can discharge a solution to an accurate position on a substrate, and can manufacture an electron source having a plurality of electron-emitting

portions with uniform electron emission characteristics.

By these apparatus and method, the present invention can effectively prevent any color misregistration of the filter element in the color filter, and can prevent any unwanted short-circuiting between driving conductors in the driving circuit for various displays.

By these apparatus and method, the present invention can also realize a small number of steps, high yield, and low cost.

#### Brief Description of the Drawings

Fig. 1 is a view showing the whole arrangement of an electron source substrate manufacturing apparatus according to the present invention;

Fig. 2 is an enlarged view showing a system for supplying a metal solution to the droplet applying unit of the electron source substrate manufacturing apparatus according to the present invention;

Fig. 3(a) is a view showing in detail a unit for removing a dissolved gas according to the first embodiment of the present invention, and Fig. 3(b) is a perspective view showing a membrane;

Fig. 4 is an enlarged view showing details of a temperature adjusting unit according to the first embodiment of the present invention;

Fig. 5 is a view showing in detail a unit for removing a dissolved gas according to the second embodiment of the present invention;

Fig. 6 is a view showing in detail a unit for  
5 removing a dissolved gas according to the third embodiment of the present invention;

Fig. 7 is a plan view showing an electron source substrate manufactured by the manufacturing apparatus according to the present invention;

10 Fig. 8 is a perspective view showing an image forming apparatus manufactured by the manufacturing apparatus according to the present invention;

Figs. 9(a) and 9(b) are a plan view and a sectional view, respectively, for explaining an example  
15 of an electron-emitting element according to the present invention;

Figs. 10(a) and 10(b) are a plan view and a sectional view, respectively, for explaining another example of the electron-emitting element according to  
20 the present invention; and

Figs. 11(a) and 11(b) are a plan view and a sectional view, respectively, showing a conventional electron-emitting element.

## 25 Best Mode for Carrying out the Invention

Preferred embodiments of the present invention will be described below with reference to the

accompanying drawings.

Fig. 9 shows schematic views of an arrangement of a surface-conduction type electron-emitting element used in the following embodiments, in which Fig. 9(a) is a plan view, and Fig. 9(b) is a sectional view. In Fig. 9, reference numeral 1 denotes a substrate; 2 and 3, element electrodes (conductors); 4, a pair of conductive films (conductors); and 5, a gap between the pair of conductive films.

As another arrangement, as shown in Figs. 10(a) and 10(b), films 4a of carbon or a carbon compound may be formed in the gap 5 and on the conductive films 4. The films of carbon or a carbon compound form a gap 5a narrower than the gap 5 to further increase the service life and electron emission efficiency.

This surface-conduction type electron-emitting element emits electrons from the conductive films 4 near the gap 5 or 5a by applying a voltage between the element electrodes 2 and 3.

As an embodiment of the present invention, a method of forming the conductive film 4 of the surface-conduction type electron-emitting element will be described. Fig. 1 is a schematic view showing an electron source substrate manufacturing apparatus using a droplet applying unit of the present invention. Fig. 2 is an enlarged view showing a system for supplying a metal solution to the droplet applying unit

in Fig. 1. In Fig. 1, reference numeral 8 denotes a droplet discharge unit; 9, a droplet; 101, a substrate (to be referred to as an MTX substrate hereinafter) immediately before a conductive thin film is formed; 15, a stage having X- and Y-direction scanning mechanisms; 16, a position detecting mechanism; and 19, a control computer. In Fig. 2, reference numeral 102 denotes a temperature adjusting unit; 103, a unit for removing a dissolved gas; 104, a unit for measuring the concentration of the dissolved gas; 105, a chamber; 106, a vacuum pump; 107, a solution containing metal elements; and 108, a tank for this solution.

The droplet discharge unit 8 is not limited to a particular unit as far as it can form an arbitrary droplet. The unit 8 can be an ink-jet type unit. The materials of the droplet 9 and solution 107 are not limited to a particular state as far as they can form droplets. The materials can be a solution, organic metal solution, or the like prepared by dispersing/dissolving a metal or the like serving as the component of the conductive thin film in water, a solvent, or the like.

This solution 107 is applied as the droplets 9 to desired positions on the element electrodes 2 and 3 by the droplet discharge unit 6. When the solution 107 contacts outside air, a gas may be dissolved in the solution to increase the dissolved gas amount in the

solution 107, or the gas may form bubbles 109, as shown in Fig. 2. If such a gas is directly discharged by the droplet discharge unit, the dissolved gas abnormally bubbles due to abrupt changes in pressure or  
5 temperature in the droplet discharge unit to make the discharge amount or discharge direction of the droplet 9 nonuniform.

If the bubbles 109 exist in the solution 107, the solution may not be sufficiently filled depending on  
10 the bubble size, and may be injected into the droplet discharge unit 6, failing to discharge the droplets 9. If the temperature of the solution changes depending on the temperature of outside air or the like, the physical properties (concentration, viscosity, and the  
15 like) of the solution 107 change to make the discharge amount of the droplet 9 nonuniform.

For this reason, droplets cannot be applied to designed positions, and the yield decreases. To prevent this, the present invention adopts the  
20 apparatus shown in Figs. 1 and 2 to apply droplets to optimal positions for all the elements and increase the yield. The procedures will be described below.

The solution 107 containing a gas is introduced into the unit 103 for removing a dissolved gas. The  
25 chamber 105 in the unit 103 selectively transmits the gas to the outside in accordance with the molecular size. In this case, the chamber 105 is formed from a

semi-transmitting film. The exhaust speed of the vacuum pump 106 can be controlled by an external signal. The dissolved gas analyzer 104 measures the concentration of the gas dissolved in the solution 107 which has passed through the chamber 105, and can output the concentration.

The solution introduced into the unit 103 is supplied to the chamber 105. The chamber 105 is evacuated by the vacuum pump 106 to selectively exhaust and remove the gas dissolved in the solution 107 through the vacuum pump 106. The gas-removed solution is introduced into the dissolved gas analyzer 104 where the concentration of the gas in the solution is measured. Based on the measurement value, the exhaust speed of the vacuum pump 106 is adjusted to control the concentration of the gas dissolved in the solution 107 to a sufficiently small value.

After these steps, the solution 107 having passed through the dissolved-gas removing unit is controlled to a desired temperature by the temperature adjusting unit 102. As shown in Fig. 4, the temperature adjusting unit 102 is constituted by a circulator 120, tube 123, constant-temperature bath 121, and water thermometer 122. The circulator 120 is controlled to set the temperature of the metal solution 107 detected by the water thermometer 121 to a default value.

After these steps, the metal solution 107 kept at



the temperature of the default value is introduced into the droplet discharge unit 8. The droplet discharge unit 8 discharges the droplets 9 in synchronism with scanning of the stage 15, and applies them to desired positions on the MTX substrate 101.

Then, the droplet-applied MTX substrate 101 is calcinated at 300°C to 400°C to form the conductive films 4.

A step, called the electrification forming step, of applying a voltage between the element electrodes 2 and 3 from a power supply (not shown) is performed to form a fissure (gap 5) in part of the conductive films 4, thereby forming electron-emitting portions in the conductive films 4. Processing called the activation step is performed for an element having undergone the electrification forming step to deposit the films 4a of carbon or a carbon compound on the conductive films (see Fig. 10).

A method of manufacturing an image forming apparatus according to the present invention will be described below.

An electron source substrate used for the image forming apparatus is formed by arraying a plurality of surface-conduction type electron-emitting elements on a substrate.

As shown in Fig. 7, the surface-conduction type electron-emitting elements are arrayed in a simple

matrix (to be referred to as a matrix layout electron source substrate hereinafter) in which a pair of element electrodes are respectively connected to X- and Y-direction wiring lines. In Fig. 7, reference numeral 5 71 denotes an electron source substrate; 72, an X-direction wiring line; 73, a Y-direction wiring line; 74, a surface-conduction type electron-emitting element; and 75, a connection line.

In Fig. 7, a substrate used for the electron source substrate 71 is the above-mentioned glass 10 substrate or the like, and the shape of the substrate is appropriately set in accordance with the intended use. M X-direction wiring lines 72 are lines Dx1, Dx2,..., Dxm, whereas n Y-direction wiring lines 73 are 15 lines Dy1, Dy2,..., Dyn.

The wiring line is formed from a conductive metal or the like by vacuum evaporation, printing, sputtering, or the like. The m X-direction wiring lines 72 and n Y-direction wiring lines 73 are 20 electrically isolated by interlevel insulating films (not shown), and constitute matrix wiring (m and n are positive integers). The interlevel insulating film (not shown) is formed from  $\text{SiO}_2$  or the like by vacuum evaporation, printing, sputtering, or the like. The 25 X-direction wiring lines 72 and Y-direction wiring lines 73 are extracted as external terminals. The surface-conduction type electron-emitting elements 74

are electrically connected to each other by the m X-direction wiring lines 72, n Y-direction wiring lines 73, and connection lines 75.

In this arrangement, individual elements can be selected and independently driven only by simple matrix wiring.

The image forming apparatus using the manufactured electron source having the simple matrix layout will be explained with reference to Fig. 8. Fig. 8 is a perspective view showing the display panel of the image forming apparatus. In Fig. 8, reference numeral 81 denotes an electron source substrate on which a plurality of surface-conduction type electron-emitting elements are arrayed; 91, a rear plate to which the electron source substrate 81 is fixed; 96, a face plate on which a fluorescent film 94, metal back 95, and the like are formed on the inner surface of a glass substrate 93; and 92, a support frame. By applying and calcinating frit glass, the rear plate 91, support frame 92, and face plate 96 are sealed to constitute an envelope 98. In Fig. 8, reference numerals 82 and 83 denote X- and Y-direction wiring lines respectively connected to a pair of element electrodes of a surface-conduction type electron-emitting element.

The glass substrate 93 is comprised of the face plate 96, support frame 92, and rear plate 91, as described above. Further, an atmospheric pressure

resistant support member called a spacer is interposed between the face plate 96 and the rear plate 91 to obtain the envelope 98 highly resistant to the atmospheric pressure.

5           The envelope 98 is sealed after being evacuated through an exhaust pipe (not shown). To maintain the vacuum degree after the envelope 98 is sealed, getter processing is done. In the image forming apparatus manufactured in this way, voltages are applied to  
10   respective surface-conduction type electron-emitting elements via the external terminals D0x1 to D0xm and D0y1 to D0yn of the vessel to emit electrons. A high voltage is applied to the face plate via a high-voltage terminal Hv to accelerate the electron beam. The  
15   electron beam is collided against the fluorescent film 94 to excite the fluorescent film 94. The fluorescent film 94 emits light to display an image.

(First Embodiment)

20           Fig. 1 is a view best showing the feature of the present invention, and shows an apparatus for forming the conductive film of a surface-conduction type electron-emitting element on an electron source substrate according to the present invention. Fig. 1  
25   is a schematic view showing an electron source substrate manufacturing apparatus according to the first embodiment of the present invention. Fig. 2 is an enlarged view showing a system for supplying a metal

solution to a droplet applying unit in Fig. 1. Fig. 3 is a view showing in detail a unit for removing a dissolved gas in Fig. 1.

The arrangement of this apparatus, and an electron source substrate manufacturing method using this apparatus will be explained. In Fig. 1, reference numeral 15 denotes a stage to which an MTX substrate 101 is fixed. The stage 15 is coupled to X- and Y-direction scanning mechanisms for moving the stage 15 in the X and Y directions, and can be moved to an arbitrary position in accordance with a signal from a stage scanning controller. The MTX substrate 101 is placed on the stage 15. A surface-conduction type electron-emitting element to be formed on an electron source substrate has the same structure as that shown in Fig. 9, and is made up of a substrate 1, element electrodes 2 and 3, and conductive films 4.

A droplet discharge unit 8 for applying droplets is located above the MTX substrate 101. In the first embodiment, the droplet discharge unit 8 is fixed to the apparatus on the XY plane. The MTX substrate 101 is moved to an arbitrary position by the XY-direction scanning mechanism 15 to realize relative movement of the droplet discharge unit 8 and MTX substrate 101.

The system for supplying a metal solution to the droplet discharge unit will be explained with reference to Fig. 2. In Fig. 2, a metal solution 107 is

temporarily stored in a tank 108, and introduced into the droplet discharge unit 8 via a temperature adjusting unit 102 and a unit 103 for removing a dissolved gas. The unit 103 is made up of a chamber 105, a vacuum pump for evacuating the chamber 105, and a dissolved gas analyzer 104. The exhaust speed of the pump is changed based on an output from the dissolved gas analyzer to control the internal pressure of the chamber.

Figs. 3(a) and 3(b) show details of the dissolved gas analyzer 104, and the unit 103 for removing a dissolved gas, and Fig. 4 shows details of the temperature adjusting unit. The chamber 105 is comprised of a membrane 112 having a semi-transmitting film, and a vessel 111 which encloses the membrane 112. The vessel 111 is evacuated by a pump 106. As shown in Fig. 3(b), the membrane 112 selectively transmits small-size molecules such as a gas via small holes formed in the surface of the membrane. The membrane 112 having this function can be mainly made of poly4-methylpenten. In the first embodiment, the chamber 105 is formed from "SEPAREL" available from Dainippon Ink & Chemicals. The dissolved gas analyzer 104 is formed from a closed vessel 114, and a DO meter 113 for measuring the concentration of oxygen dissolved in the solution. The dissolved gas analyzer 104 determines the concentration of a gas dissolved in the

solution on the basis of oxygen dissolved in the solution 107 in the closed vessel 114.

Fig. 4 shows details of the temperature adjusting unit 102. The temperature adjusting unit 102 comprises a circulator 120, tube 123, constant-temperature bath 121, and water thermometer 122. The circulator is used to circulate through the tube 123 a liquid kept at a constant temperature, thereby keeping the temperature of a liquid in the constant-temperature bath 121 constant.

Driving of the droplet discharge unit 6 is controlled by an ink-jet head control/driving unit 18 so as to discharge droplets from the droplet discharge unit 6 at an arbitrary timing. The ink-jet head control/driving unit is controlled by a control computer 19. As the droplet discharge unit 6, an ink-jet type unit can be adopted. This embodiment adopts a bubble-jet type unit.

A method of operating the electron source substrate manufacturing apparatus in the first embodiment will be explained with reference to Figs. 1 to 3. As described above, the metal solution 107 is introduced into the droplet discharge unit 6, and applied as a droplet 9 to a predetermined position on the MTX substrate 101. The metal solution 107 contains a dissolved gas with an irregular concentration that dissolves from contact air, and bubbles 109 generated

by shock or the like. If the metal solution is introduced into the droplet discharge unit 6 in this state, in discharging the droplet 9,

(1) The gas dissolved in the metal solution  
5 abnormally bubbles owing to abrupt changes in heat or pressure to nonuniformly change the discharge amount or discharge direction of the droplet 9.

(2) The droplet discharge unit 6 is not  
satisfactorily filled with the metal solution 107 due  
10 to bubbles in the metal solution 107, and the droplet 9 greatly decreases in discharge amount or cannot be discharged.

At the same time, the discharge direction also changes nonuniformly to impair the uniformity of the  
15 manufactured electron source substrate. Furthermore, the temperature of the solution changes depending on the temperature of outside air or the like, and the physical properties (concentration, viscosity, and the like) of the solution 107 change to make the discharge  
20 amount of the droplet 9 nonuniform.

This phenomenon occurs not only when the droplet discharge unit 6 is a bubble-jet type unit as in the first embodiment, but also when the droplet discharge unit 6 is a piezo-jet type unit. The uniformity of the  
25 electron source substrate 71 is difficult to maintain, which decreases the yield.

The apparatus of the first embodiment solves this



problem by the following procedures, which will be explained with reference to Figs. 1 to 3.

1. The metal solution 107 is introduced from the solution tank 108 to the chamber 105. At this time,  
5 the metal solution 107 contains a gas and the bubbles 109 at an irregular concentration that are generated when the metal solution 107 contacts outside air or shock is applied to the metal solution 107 in the manufacture or safekeeping.
- 10 2. The metal solution 107 introduced into the chamber 105 is injected into the membrane 112. By evacuating the chamber by the vacuum pump 106, small-size molecules in the gas and bubbles dissolved in the metal solution 107 transmit through the wall  
15 surface of the membrane, and are exhausted outside the chamber. Since the gas and bubbles 109 dissolved in the solution are mainly  $N_2$ ,  $O_2$ ,  $CO_2$ , the gas in the metal solution can be selectively removed by this method.
- 20 3. The metal solution 107 from which the dissolved gas and bubbles 109 are removed in the chamber 105 in step 2 is introduced into the dissolved gas analyzer 104. The metal solution 107 is injected into the closed vessel 114, and the DO meter 113 is  
25 inserted into the closed vessel 114 to measure the concentration of the gas dissolved in the metal solution 107. The first embodiment pays attention to  $O_2$

among the components of the dissolved gas because the amount of  $O_2$  is relatively large and its dissolved amount can be measured at high precision. The dissolved amount of  $O_2$  is measured to determine an expected amount of dissolved gas. During measurement, the metal solution 107 is always stirred using a rotator 115 to increase the measurement precision.

4. The exhaust speed of the pump is controlled based on the dissolved  $O_2$  concentration measured in step 3 so as to set the dissolved  $O_2$  concentration to a proper value for the following purposes.

(i) The dissolved gas is exhausted to a value at which discharge of droplets from the droplet discharge unit 8 satisfactorily stabilizes.

(ii) If the vacuum degree in the chamber 105 excessively decreases, the main component (solvent and the like) of the metal solution 107 is exhausted to change the concentration. To prevent this, the dissolved gas amount must be prevented from excessively decreasing.

5. The metal solution 107 after steps 2 to 4 is introduced into the temperature adjusting unit 102. In the temperature adjusting unit 102, the circulator 120 circulates through the tube 123 a liquid kept at a temperature of  $20^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$  to keep the temperature of the metal solution 107 in the constant-temperature bath 121 constant. The structure of the temperature

adjusting unit (the volume of the constant-temperature bath 121, the shape of the fluid passage of the tube 123, and the like) is designed to set the temperature of the metal solution 107 in use to  $20^{\circ}\text{C} \pm 0.3^{\circ}\text{C}$ . The  
5 first embodiment assumes application of droplets at a discharge amount of 50 pl per operation and a discharge frequency of 1 kHz. The volume of the constant-temperature bath is designed to 15 ml.

After the temperature of the metal solution is  
10 controlled to a predetermined value by this method, the metal solution is introduced into the droplet discharge unit 6.

In this manner, the droplets 9 containing a conductive film formation material are applied four  
15 times. The resultant substrate is heated at  $300^{\circ}\text{C}$  for 10 min to form thin films from palladium oxide ( $\text{PdO}$ ) at a film thickness of  $100 \text{ \AA}$  as conductive films. A voltage is applied between the pair of electrodes 2 and 3, and electrification processing (electrification  
20 forming processing) is performed for the conductive films 4 to form a gap 5 between the conductive films 4.

The manufactured electron source substrate is used to constitute an envelope 98 by a face plate 96, support frame 92, and rear plate 91, as shown in  
25 Fig. 8. The envelope 98 is sealed to manufacture a display panel and an image forming apparatus having a driving circuit for performing television display on

the basis of an NTSC television signal.

An electron-emitting element manufactured by the manufacturing method of the first embodiment exhibits good characteristics, and the conductive thin film can be uniformly implemented on the substrate with high quality. The present invention can obtain at high yield a high-quality image forming apparatus almost free from variations in element characteristics at the same degree as element characteristics attained by photolithography.

(Second Embodiment)

A method of manufacturing an image forming apparatus having a surface-conduction type electron-emitting element according to the second embodiment of the present invention will be described with reference to Fig. 5. The second embodiment is the same as the first embodiment except that the concentration of a gas dissolved in a metal solution 107 is controlled by the opening degree of a valve 117.

When the exhaust speed of a vacuum pump 106 is set constant, the concentration of the gas dissolved in the metal solution 107 depends on the stay time in a chamber 105. In the second embodiment, the three-way valve 117 is interposed between the chamber 105 and a dissolved gas analyzer 104. The opening degree of the three-way valve 117 is controlled based on a dissolved  $O_2$  concentration detected by a DO meter 113, and part of

the metal solution 107 is exhausted to the outside. This changes the stay time in the chamber 105 so as to keep the concentration of the gas dissolved in the metal solution 117 constant.

5           This method can also control the concentration of the gas dissolved in the metal solution 107 to a predetermined value or less, and can increase the yield of the electron source substrate, similar to the first embodiment. The second embodiment realizes the control  
10       method using the opening degree of the valve, and thus can simplify the apparatus.

(Third Embodiment)

          A method of manufacturing an image forming  
apparatus having a surface-conduction type  
15       electron-emitting element according to the third embodiment of the present invention will be described with reference to Fig. 6. The third embodiment is the same as the first embodiment except that the  
concentration of a gas dissolved in a metal solution  
20       107 is controlled by a pressure value in a chamber 105.

          When discharge of droplets 9 from a droplet  
discharge unit 6 is maintained at a predetermined speed  
in manufacturing an electron source substrate, the stay  
time of the metal solution 107 in the chamber 105 is  
25       constant. At this time, the concentration of the gas dissolved in the metal solution 107 depends on the vacuum degree in the chamber 105. From this, as shown

in Fig. 6, a vacuum gauge 119 is arranged in the chamber 105. A pump control unit 110 is controlled based on the value of the pressure gauge 119 to keep the vacuum degree in the chamber 105 at a proper value.

5           This method can also control the concentration of the gas dissolved in the metal solution 107 to a predetermined value or less, and can increase the yield of the electron source substrate, similar to the first embodiment. The third embodiment uses the pressure  
10          gauge 119 as a method of obtaining the concentration of the dissolved gas, and thus can simplify the apparatus.

#### Industrial Applicability

          The present invention can provide an electronic  
15        device manufacturing method and manufacturing apparatus which can discharge a solution to an accurate position on a substrate, and are excellent in reproducibility of the characteristics of a manufactured electronic device.

20        The present invention can provide a manufacturing method and manufacturing apparatus which can discharge a solution to an accurate position on a substrate, for an electron source having a plurality of electron-emitting portions with uniform electron  
25        emission characteristics.

          The present invention can provide a manufacturing method for a high-quality image forming apparatus

having uniform emission luminance.

An electron source substrate manufactured by these apparatus and method can realize a smaller number of steps, higher yield, and lower cost, compared to the conventional manufacturing method.

C L A I M S

1. An electronic device manufacturing apparatus  
for manufacturing an electronic device, characterized  
5 by comprising:

gas removal means for removing a gas dissolved in  
a liquid containing a formation material of a member  
constituting the electronic device;

droplet discharge means for discharging droplets  
10 of the liquid; and

means for controlling relative positions of said  
droplet discharge means and a substrate on which the  
electronic device is formed,

wherein the droplets are applied to a  
15 predetermined position on the substrate.

2. An electronic device manufacturing apparatus  
according to claim 1, characterized in that said gas  
removal means comprises a closed vessel filled with a  
20 membrane formed from a semi-transmitting film capable  
of transmitting a gas, and a vacuum unit for evacuating  
the closed vessel.

3. An electronic device manufacturing apparatus  
25 according to claim 2, characterized in that said gas  
removal means comprises means for adjusting a flow rate  
of the liquid in the membrane.



4. An electronic device manufacturing apparatus according to claim 1, characterized in that said gas removal means comprises means for detecting an amount of gas contained in the liquid.

5

5. An electronic device manufacturing apparatus according to claim 1, characterized in that said gas removal means comprises a vacuum unit, and exposes a solution containing the liquid to vacuum.

10

6. An electronic device manufacturing apparatus according to claim 5, characterized in that the vacuum unit has a variable exhaust speed.

15

7. An electronic device manufacturing apparatus according to claim 5, characterized in that said gas removal means comprises means for detecting a vacuum degree of the vacuum unit.

20

8. An electronic device manufacturing apparatus according to claim 1, characterized in that said droplet discharge means generates a bubble in the liquid using thermal energy, and discharges the liquid on the basis of generation of the bubble.

25

9. An electronic device manufacturing apparatus according to claim 1, characterized in that said

droplet discharge means discharges the liquid using kinematic energy.

10. An electronic device manufacturing apparatus  
5 for manufacturing an electronic device, characterized by comprising:

means for adjusting a temperature of a liquid containing a formation material of a member constituting the electronic device;

10 droplet discharge means for discharging droplets of the liquid; and

means for controlling relative positions of said droplet discharge means and a substrate on which the electronic device is formed,

15 wherein the droplets are applied to a predetermined position on the substrate.

11. An electronic device manufacturing apparatus according to claim 10, characterized in that said  
20 droplet discharge means generates a bubble in the liquid using thermal energy, and discharges the liquid on the basis of generation of the bubble.

12. An electronic device manufacturing apparatus  
25 according to claim 10, characterized in that said droplet discharge means discharges the liquid using kinematic energy.

13. An electronic device manufacturing apparatus according to any one of claims 1 to 12, characterized in that the electronic device includes an electron source having a plurality of electron-emitting elements.

14. An electronic device manufacturing apparatus according to claim 13, characterized in that each electron-emitting element includes an electron-emitting element having a pair of conductors arranged at a gap.

15. An electronic device manufacturing apparatus according to claim 14, characterized in that said droplet discharge means includes means for discharging droplets of the liquid containing a formation material of the conductors.

16. An electronic device manufacturing apparatus according to claim 13, characterized in that the electron source includes an electron source having a plurality of electron-emitting element arrays each formed by connecting a plurality of electron-emitting elements between a pair of wiring lines.

17. An electronic device manufacturing apparatus according to claim 13, characterized in that the electron source includes an electron source constituted

by connecting a plurality of electron-emitting elements in a matrix by a plurality of row-direction wiring lines and a plurality of column-direction wiring lines.

5           18. An electron source substrate manufacturing apparatus for manufacturing an electron source substrate having a plurality of pairs of element electrodes formed on a substrate, conductive films each having an electron-emitting portion formed between each  
10 pair of element electrodes, and a voltage application terminal to each element electrode, characterized by comprising:

gas removal means for removing a gas dissolved in a solution containing a metal element;

15           droplet discharge means for discharging droplets of the solution containing the metal element; and

means for controlling relative positions of said droplet discharge means and the substrate,

wherein the droplets are applied to a  
20 predetermined position on the substrate.

19. An electron source substrate manufacturing apparatus according to claim 18, characterized in that said gas removal means comprises a closed vessel filled  
25 with a membrane formed from a semi-transmitting film capable of transmitting a gas, and a vacuum unit for evacuating the closed vessel.

20. An electron source substrate manufacturing apparatus according to claim 19, characterized in that said gas removal means comprises means for adjusting a flow rate of a metal solution in the membrane.

5

21. An electron source substrate manufacturing apparatus according to claim 18, characterized in that said gas removal means comprises means for detecting an amount of gas contained in the solution.

10

22. An electron source substrate manufacturing apparatus according to claim 18, characterized in that said gas removal means comprises a vacuum unit, and exposes a solution containing a metal solution to vacuum.

15

23. An electron source substrate manufacturing apparatus according to claim 22, characterized in that the vacuum unit has a variable exhaust speed.

20

24. An electron source substrate manufacturing apparatus according to claim 22, characterized in that said gas removal means comprises means for detecting a vacuum degree of the vacuum unit.

25

25. An electron source substrate manufacturing apparatus for manufacturing an electron source

substrate having a plurality of pairs of element electrodes formed on a substrate, conductive films each having an electron-emitting portion between each pair of element electrodes, and a voltage application terminal to each element electrode, characterized by comprising:

means for adjusting a temperature of a solution containing a metal element;

droplet discharge means for discharging droplets of the solution containing the metal element; and

means for controlling relative positions of said droplet discharge means and the substrate,

wherein the droplets are applied to a predetermined position on the substrate.

26. An electron source substrate manufacturing apparatus according to claim 18 or 25, characterized in that said droplet discharge means generates a bubble in the solution using thermal energy, and discharges the solution on the basis of generation of the bubble.

27. An electron source substrate manufacturing apparatus according to claim 18 or 25, characterized in that said droplet discharge means discharges the solution using kinematic energy.

28. An electron source substrate manufacturing

apparatus according to claim 18 or 25, characterized in that the solution containing the metal element contains a formation material of the conductive film in which the electron-emitting portion is formed.

5

29. An electronic device manufacturing method characterized by comprising:

the gas removal step of removing a gas dissolved in a liquid containing a formation material of a member constituting an electronic device; and

the droplet discharge step of discharging droplets by droplet discharge means while controlling relative positions of the droplet discharge means for discharging droplets of the liquid and a substrate on which the electronic device is formed, thereby applying the droplets to a predetermined position on the substrate.

30. An electronic device manufacturing method according to claim 29, characterized in that the gas removal step comprises controlling a concentration of the gas dissolved in the liquid so as to be kept at a default value.

31. An electronic device manufacturing method according to claim 29, characterized in that the droplet discharge means generates a bubble in the

liquid using thermal energy, and discharges a solution on the basis of generation of the bubble.

32. An electronic device manufacturing method  
5 according to claim 29, characterized in that the droplet discharge means discharges the liquid using kinematic energy.

33. An electronic device manufacturing method  
10 characterized by comprising:  
the temperature adjusting step of adjusting a temperature of a liquid containing a formation material of a member constituting an electronic device; and  
the droplet discharge step of discharging droplets  
15 by droplet discharge means while controlling relative positions of the droplet discharge means for discharging droplets of the liquid and a substrate on which the electronic device is formed, thereby applying the droplets to a predetermined position on the  
20 substrate.

34. An electronic device manufacturing method  
according to claim 33, characterized in that the droplet discharge means generates a bubble in the  
25 liquid using thermal energy, and discharges the liquid on the basis of generation of the bubble.



35. An electronic device manufacturing method according to claim 33, characterized in that the droplet discharge means discharges the liquid using kinematic energy.

5

36. An electronic device manufacturing method according to any one of claims 29 to 35, characterized in that the electronic device includes an electron source having a plurality of electron-emitting elements.

10

37. An electronic device manufacturing method according to claim 36, characterized in that each electron-emitting element includes an electron-emitting element having a pair of conductors arranged at a gap.

15

38. An electronic device manufacturing method according to claim 37, characterized in that the liquid includes a liquid containing a formation material of the conductors.

20

39. An electronic device manufacturing method according to claim 36, characterized in that the electron source includes an electron source having a plurality of electron-emitting element arrays each formed by connecting a plurality of electron-emitting elements between a pair of wiring lines.

25

40. An electronic device manufacturing method according to claim 36, characterized in that the electron source includes an electron source constituted by connecting a plurality of electron-emitting elements in a matrix by a plurality of row-direction wiring lines and a plurality of column-direction wiring lines.

41. An electron source substrate manufacturing method of manufacturing an electron source substrate having a plurality of pairs of element electrodes formed on a substrate, conductive films each having an electron-emitting portion formed between each pair of element electrodes, and a voltage application terminal to each element electrode, characterized by comprising:

the gas removal step of removing a gas dissolved in a solution containing a metal element; and

the droplet discharge step of discharging droplets by droplet discharge means while controlling relative positions of the substrate and the droplet discharge means for discharging droplets of the solution, thereby applying the droplets to a predetermined position on the substrate.

42. An electron source substrate manufacturing method according to claim 41, characterized in that the gas removal step comprises controlling a concentration of the gas dissolved in the solution so as to be kept

at a default value.

43. An electron source substrate manufacturing method according to claim 41, characterized in that the  
5 droplet discharge means generates a bubble in the solution using thermal energy, and discharges the solution on the basis of generation of the bubble.

44. An electron source substrate manufacturing  
10 method according to claim 41, characterized in that the droplet discharge means discharges the solution using kinematic energy.

45. An electron source substrate manufacturing  
15 method of manufacturing an electron source substrate having a plurality of pairs of element electrodes formed on a substrate, conductive films each having an electron-emitting portion formed between each pair of element electrodes, and a voltage application terminal  
20 to each element electrode, characterized by comprising:  
the temperature adjusting step of adjusting a temperature of a solution containing a metal element;  
and

the droplet discharge step of discharging droplets  
25 by droplet discharge means while controlling relative positions of the substrate and the droplet discharge means for discharging droplets of the solution, thereby

applying the droplets to a predetermined position on the substrate.

46. An electron source substrate manufacturing  
5 method according to claim 45, characterized in that the droplet discharge means generates a bubble in the solution using thermal energy, and discharges the solution on the basis of generation of the bubble.

10 47. An electron source substrate manufacturing method according to claim 45, characterized in that the droplet discharge means discharges the solution using kinematic energy.

15 48. An electron source substrate manufacturing method according to claim 41 or 45, characterized in that the solution containing the metal element contains a formation material of the conductive film in which the electron-emitting portion is formed.

20 49. An image forming apparatus manufacturing method of manufacturing an image forming apparatus having an electron source substrate and a light-emitting member which emits light upon  
25 irradiation of electrons from the electron source substrate, characterized in that

the electron source substrate is manufactured by the method defined in claim 41 or 45.

A B S T R A C T

An electronic device manufacturing apparatus includes a gas removal means for removing a gas dissolved in a liquid containing the formation material of a member constituting an electronic device, a  
5       droplet discharge means for discharging droplets of the liquid, and a means for controlling the relative positions of the droplet discharge means and a substrate on which the electronic device is formed.

10       The droplets are applied to a predetermined position on the substrate. The gas removal means includes a closed vessel filled with a membrane formed from a semi-transmitting film capable of transmitting a gas, and a vacuum unit for evacuating the closed vessel.

FIG. 1

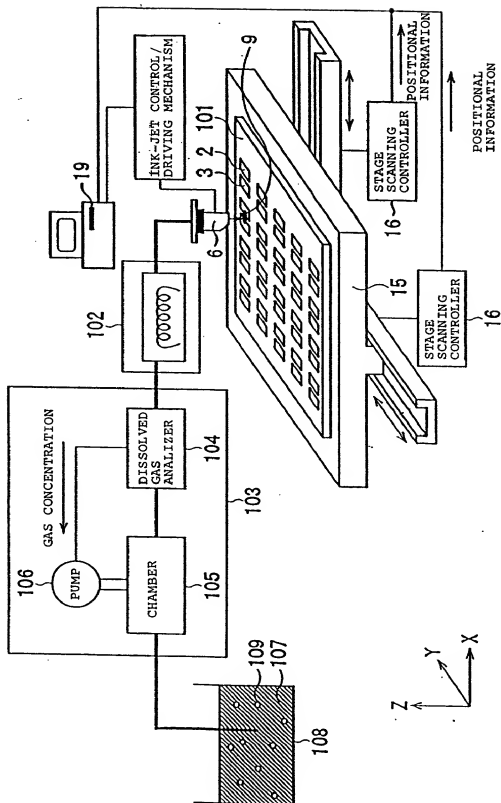


FIG. 2

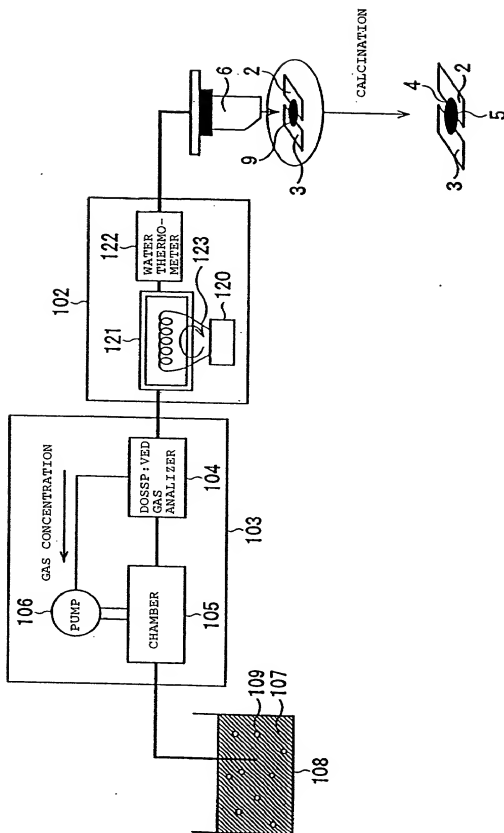


FIG. 3

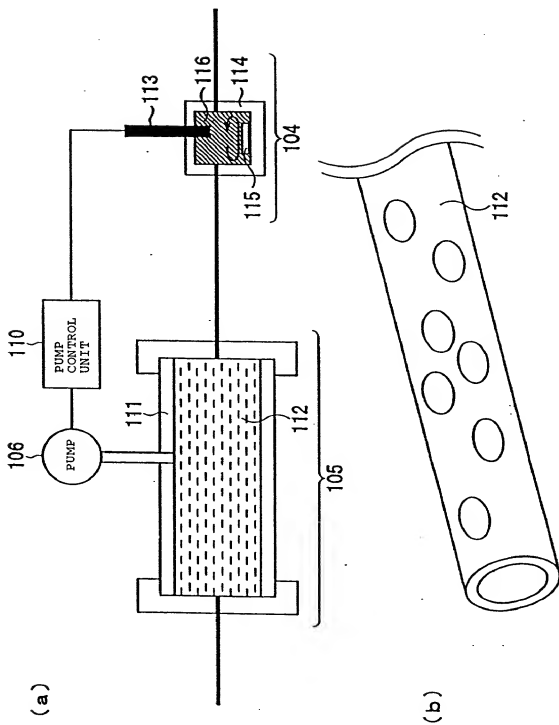




FIG. 4

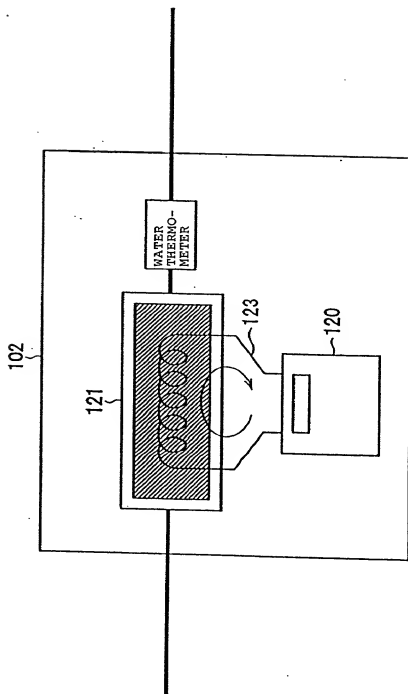


FIG. 5

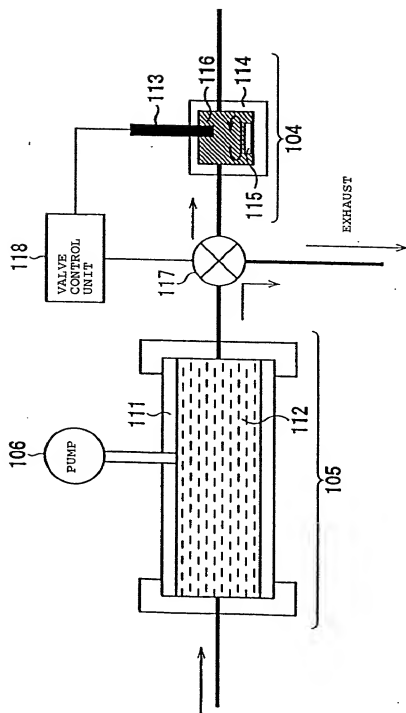


FIG. 6

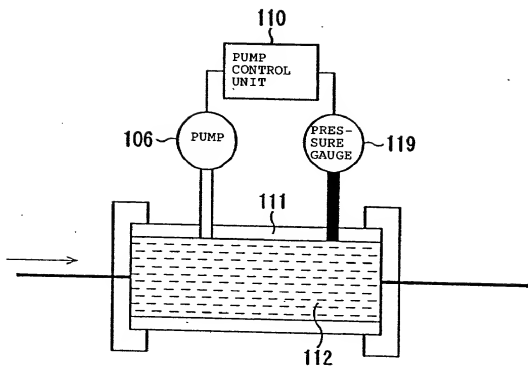


FIG. 7

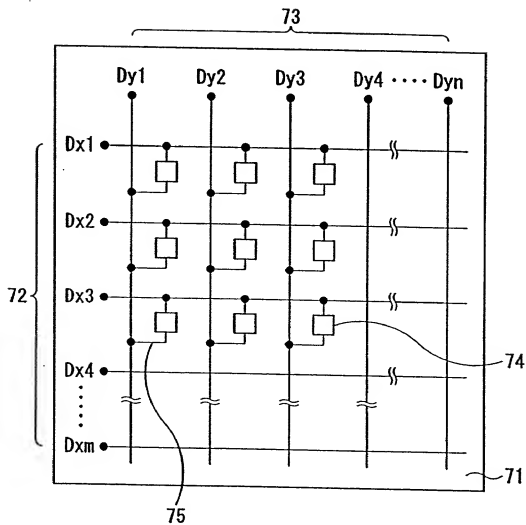


FIG. 8

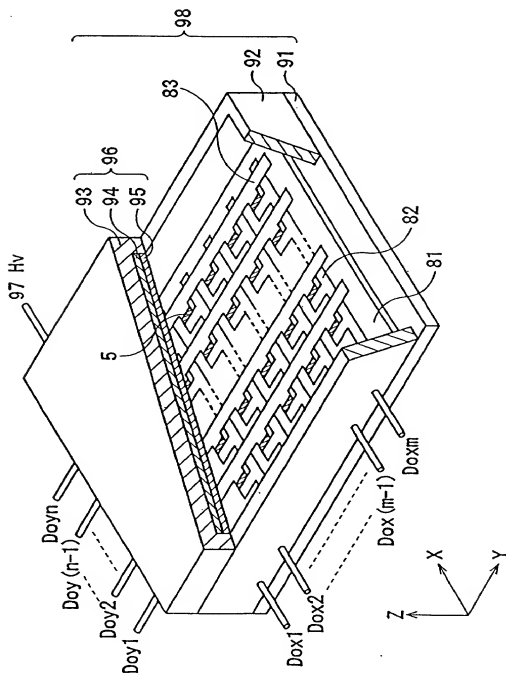


FIG. 9

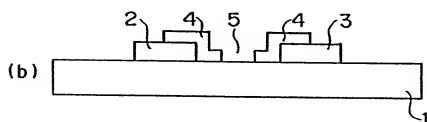
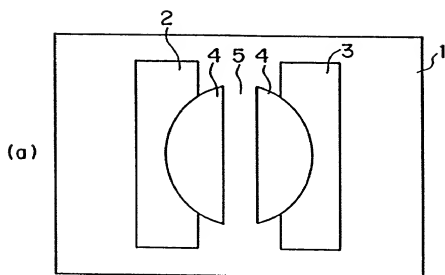


FIG. 10

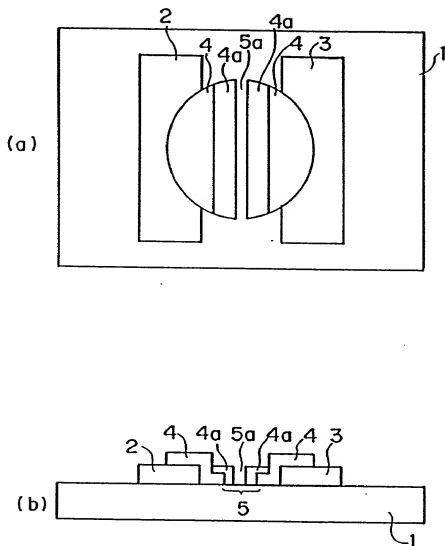
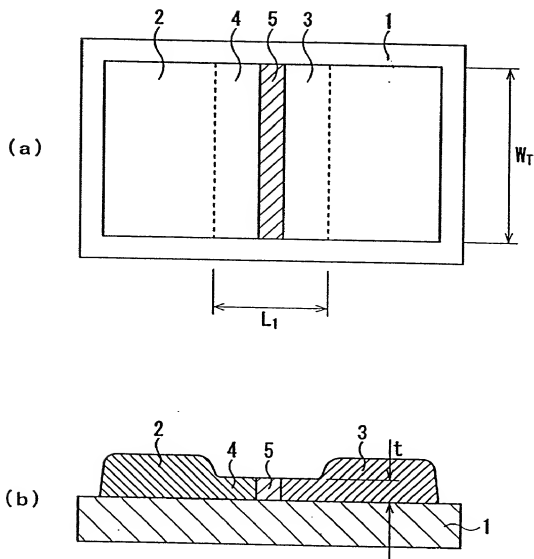


FIG. 11





270 1432 23

**COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR PATENT APPLICATION**  
(Page 1)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled METHOD OF MANUFACTURING ELECTRONIC DEVICE, ELECTRON SOURCE SUBSTRATE, AND IMAGE FORMING APPARATUS, AND APPARATUS FOR MANUFACTURING ELECTRONIC DEVICE AND ELECTRON SOURCE SUBSTRATE

the specification of which ☐ is attached hereto ☒ was filed on February 23, 2000 as United States Application  
No. or PCT International Application No. PCT/JP00/01024  
and was amended on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or §365(b), of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designates at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed:

Country	Application No.	Filed (Day/Mo./Yr.)	(Yes/No) Priority Claimed
JAPAN	11-047095	24 February 1999	Yes

I hereby appoint the practitioners associated with the firm and Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, and direct that all correspondence be addressed to the address associated with that Customer Number:

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Customer Number: 05514

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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